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APPENDIX B

APPENDIX B

COMPARATIVE ANALYSIS OF SYSTEM PROPOSALS

The FCC has proposed licensing additional NVNG MSS systems in the spectrum allocated at WARC-92. The following analysis evaluates the viability of each of the Notices' proposed license allocations: Little LEO System 1, System 2 and System 3. In summary this analysis indicates that the proposed approach does not make efficient use of the available spectrum and will not support economically viable competitors. As a result of this analysis Leo One USA recommends an alternative proposal that maximizes the efficient use of the spectrum and supports two economically viable systems: System A and System B. Support for this conclusion is presented below and in the accompanying economic analysis contained in Appendix A. Finally, an analysis is made of the increase to the Orbcomm system capacity if its pending second round amendment requesting additional spectrum is granted, rather than introducing additional competitive systems.

Because Orbcomm represents the largest licensee, Orbcomm's 36 satellite system is used as the relative standard for comparing the capacities of the three spectrum allocations proposed by the Commission, the alternate two allocations proposed by Leo One USA, and Orbcomm's proposed modified allocation. The following sections calculate what the capacity of Orbcomm's 36 satellite system would be if it were constrained to operate in each of the proposed allocations.

Orbcomm's authorized 36 satellite system consists of four planes of eight satellites each inclined at 45° to the equator and two planes of two satellites each inclined at 70°. The 45° inclined planes are separated by 135°, the satellites in each plane by 45°, and the inter-plane

phasing angle is 0°. The 70° inclined planes are separated by 180°, the satellites in each plane by 90°, and the inter-plane phasing angle is 0°.

Assuming a 10° elevation mask, an average of 1.4 satellites are visible to a subscriber at 36° latitude. Each satellite has a subscriber downlink capacity of 9.6 kbps. Thus Orbcomm's average subscriber downlink capacity is 1.4 x 9.6 kbps x 86,400 sec/day = 1,160 Mbits per day.

To achieve this capacity, Orbcomm uses 320 kHz of spectrum in the 137 - 138 MHz downlink band, 270 kHz for subscriber links and 50 kHz for gateway links. Orbcomm also has access, on a shared basis, to 995 kHz of spectrum in the 148 - 149.9 MHz band, 50 kHz of which is used for gateway uplinks and 945 kHz for subscriber uplinks. Since Orbcomm had the opportunity to engineer its spectrum requirements, it is assumed that Orbcomm's system is balanced, i.e., that the 945 kHz of shared 149 MHz subscriber uplink spectrum supports the same 1,160 Mbits per day.

Orbcomm uses 15.6% (50 kHz out of 320 kHz) of its available downlink spectrum for gateway operation, the same ratio is assumed for the proposed allocations. Orbcomm's uplink and downlink gateway spectrum is balanced, 50 kHz in each direction, the same balance is assumed for the proposed new allocations.

For purposes of comparison, Starsys' authorized 24 satellite system consists of six planes of four satellites each inclined at 53° to the equator. The planes are separated by 60°, the satellites in each plane by 90°, and the inter-plane phasing angle is 0°.

Assuming a 10° elevation mask, an average of 1.22 satellites are visible to a subscriber at 36° latitude. Each satellite has a subscriber downlink capacity of 2.4 kbps. Thus, Starsys'

average subscriber downlink capacity is 1.22 x 2.4 kbps x 86,400 sec/day = 253 Mbits per day, approximately 22% of Orbcomm's capacity.

Table 1 summarizes the results. Table 2 describes the proposed frequency pairing for System A and System B. The conclusion is that System 1 is economically unviable, System 2 is non-optimal, and System 3 is both economically unviable and competitively handicapped by being prohibited in its allocation from serving maritime and aeronautical markets. Systems A and B make efficient use of the spectrum, create two economically viable licensees and are able to serve land, maritime, and aeronautical markets, effectively leading to a competitive marketplace.

Table 1. Capacity of Orbcomm System if Operated in NPRM System 1, 2, or 3, or if Operated in New System A, or B or if Orbcomm Second Round Amendment is Granted.

	Downlink as % of Orbcomm	Uplink as % of Orbcomm	Balanced as % of Orbcomm
NPRM System-1	5.7%	9.1%	5.7%
NPRM System-2	92%	84%	84%
NPRM System-3	85%	16%	16%
System A	90%	98%	90%
System B	92%	98%	92%
Modified Orbcomm	128%	116%	116%

Table 2. Frequency Pairing for Proposed System A and System B

	System A	System B	Sharing
Uplink	148.905 - 149.810 MHz 149.810 - 149.855 MHz 150.000 - 150.050 MHz	148.905 - 149.810 MHz 149.855 - 149.900 MHz 149.950 - 150.000 MHz	with Orbcomm and terrestrial time-shared with VITA LMSS and shared with RNSS
Downlink	400.150 - 400.505 MHz 400.505 - 400.5517 MHz 400.645 - 401.000 MHz		time shared with DMSP time shared with VITA time shared with DMSP
Downlink		137.025 - 137.175 MHz 137.333 - 137.367 MHz 137.753 - 137.787 MHz 137.825 - 138.000 MHz	time shared with NOAA time shared with NOAA time shared with NOAA time shared with NOAA

NPRM System 1

The Commission proposes that this system use the 149.81 - 149.9 MHz band for uplink and the 400.5050 - 400.5517 MHz band for downlink. All of this spectrum must be time-shared with VITA, which is authorized to operate a one satellite system. At 36° latitude, the VITA satellites will be visible approximately 5% of the time. Downlinks in the 400 MHz band require Doppler guard bands 2.9 times larger then those at 138 MHz. Each Orbcomm downlink channel requires 6.1 kHz of Doppler guard band. At 400 MHz, each downlink channel requires 17.7 kHz of Doppler guard band. Thus 11.6 kHz of additional guard band is required for each downlink channel.

- Downlink [400.5050 - 400.5517 MHz]

Available downlink spectrum	46.7 kHz
-15.6% for gateway operation same ratio as Orbcomm	-7.3 kHz
-23.2 kHz additional Doppler guard bands for two channels one gateway and one subscriber	-23.2 kHz
=Equivalent 138 MHz subscriber downlink spectrum	16.2 kHz
x 1,160 Mbits per day / 270 kHz	70 Mbits/day
-5% cessation of transmission to coordinate with VITA NPRM @ 46	- 4 Mbits/day
Total Downlink Capacity	66 Mbits/day
As a percentage of Orbcomm capacity	5.7 %

- Uplink [149.81 - 149.9 MHz]

Available uplink spectrum	90 kHz
-spectrum for gateway operation balance with downlink	-7.3 kHz
=Effective subscriber spectrum	82.7 kHz
x 1,160 Mbits per day / 945 kHz	102 Mbits/day
-5% cessation of transmission to coordinate with VITA NPRM @ 46	-5 Mbits/day
Total Uplink Capacity	97 Mbits/day
As a percentage of Orbcomm capacity	8.4%

System-1 provides 5.7% of Orbcomm's balanced capacity.

NPRM System 2

The Commission proposes that this system use the 148.905 - 149.81 MHz band for uplinks and a number of segments of the 137 - 138 MHz band for downlinks. The uplink spectrum is shared with Orbcomm. The 137.333 - 137.367 MHz and 137.753 - 137.787 MHz segments are available for 100% duty-cycle utilization after the NOAA satellites become

inoperable. Use of the 137.025 - 137.175 MHz and 137.825 - 138 MHz segments must be time-shared with NOAA.

- Downlink [137 - 138 MHz]

Available downlink spectrum	393 kHz
-15.6% for gateway operation same ratio as Orbcomm	-61 kHz
= Equivalent 138 MHz subscriber downlink spectrum	332 kHz
x 1,160 Mbits per day / 270 kHz	1,426 Mbits/day
-25% cessation of transmission to coordinate with NOAA NPRM @ 55 & 70	-357 Mbits/day
Total Downlink Capacity	1,069 Mbits/day
As a percentage of Orbcomm capacity	92%

- Uplink [148.905 - 149.81 MHz]

Available uplink spectrum	905 kHz
-50 kHz for avoiding Orbcomm's gateway	-50 kHz
-gateway operation balance with downlink	-61 kHz
=Effective subscriber spectrum	794 kHz
x 1,160 Mbits per day / 945 kHz	975 Mbits/day
Total Uplink Capacity	975 Mbits/day
As a percentage of Orbcomm capacity	84%

System-2 provides 84% of Orbcomm's balanced capacity.

NPRM System 3

The Commission proposes that this system use the 149.95 - 150.05 MHz band for uplinks, and the 400.150 - 400.505 MHz and 400.645 - 401 MHz band segments for downlinks. Downlinks in the 400 MHz band require Doppler guard bands 2.9 times larger then those at 138 MHz, thus 11.6 kHz of additional guard band is required for each downlink channel. The uplink

spectrum is allocated for land-mobile satellite service (LMSS) and thus this system will be precluded from providing service to airplanes and ships. The uplink spectrum is also shared with the Russian radio-navigation satellite service (RNSS). The downlink spectrum must be time-shared with DMSP. Each DMSP satellite is assigned one of the two sub-bands, footprint overlap with a DMSP satellite requires that this system cease transmission in that sub-band.

- Downlink [400.150 - 400.505 MHz & 400.645 - 401 MHz]

Available downlink spectrum	710 kHz
-Gateway spectrum with increased Doppler guard bands 1 channel in each segment required for DMSP coordination	-123 kHz
-244 kHz additional Doppler guard bands for 20 channels 10 channels per segment using all available spectrum	-244 kHz
= Equivalent 138 MHz subscriber downlink spectrum	343 kHz
x 1,160 Mbits per day / 270 kHz	1,474 Mbits/day
-33.3% cessation of transmission to coordinate with DMSP 20% both sub-bands & 26.6% one sub-band	-491 Mbits/day
Total Downlink Capacity	983 Mbits/day
As percentage of Orbcomm capacity	85%

- Uplink [149.95 - 150.05 MHz]

Available uplink spectrum	100 kHz
-Gateway spectrum balance with downlink	-50 kHz
=Effective subscriber spectrum	50 kHz
5 10-kHz channels @ 2.4 kbps each reduced by 36% S-ALOHA efficiency	373 Mbits/day
-50% to account for RNSS sharing	-186 Mbits/day
Total Uplink Capacity	187 Mbits/day
As percentage of Orbcomm capacity	16%

System-3 provides 16% of Orbcomm's balanced capacity. Additionally, this system is severely handicapped by only being able to address Land Mobile Satellite Services whereas Orbcomm can address Land, Maritime, and Aeronautical Mobile Satellite Services.

System A

Leo One USA proposes that System A use the combined downlink spectrum of NPRM System 1 and NPRM System 3. For the uplink it is proposed that the spectrum available for narrowband operation be used equally by System A and System B.

Specifically, the 400.15 - 400.505 MHz and 400.645 - 401 MHz bands (time-shared with DMSP), and the 400.505 - 400.5517 MHz band (time-shared with VITA) for downlinks; and the 150.00 - 150.05 MHz band (allocated LMSS, no sea or air use, and shared with RNSS) and the 149.81 - 149.855 MHz band (time-shared with VITA), plus the 148.905 - 149.81 MHz band (dynamically shared with Orbcomm and System B) for uplink.

- Downlink [400.15 - 400.505 MHz & 400.505 - 400.5517 MHz & 400.645 - 401 MHz]

NPRM System 1 Downlink Capacity	66 Mbits/day
+NPRM System 3 Downlink Capacity	983 Mbits/day
Total Downlink Capacity	1,049 Mbits/day
As percentage of Orbcomm capacity	90%

- Uplink [148.905 - 149.81 MHz & 149.81 - 149.855 MHz & 150.00 - 150.05 MHz]

Available uplink spectrum	
DCAAS sharing w/Orbcomm	905 kHz
+ 50% of System 1 Uplink	42.8 kHz
effectively reduced by 5% for coordination w/VITA, NPRM@46	
- 50 kHz for avoiding Orbcomm's gateway	-50 kHz
- Gateway spectrum	-50 kHz
balanced with downlink	
= Effective subscriber spectrum	848 kHz
x 1,160 Mbits per day / 945 kHz	1,041 Mbits/day
+ 50% of NPRM System 3 uplink capacity	94 Mbits/day
Total Uplink Capacity	1,135 Mbits/day
As percentage of Orbcomm capacity	98 %

System-A provides 90% of Orbcomm's balanced capacity and is capable of addressing Land, Maritime, and Aeronautical Mobile Satellite Services.

System B

Leo One USA proposes that System B use the downlink spectrum of NPRM System 2. For the uplink it is proposed that the spectrum available for narrowband operation be used equally by System A and System B.

Specifically, the 137.333 - 137.367 MHz and 137.753 - 137.787 MHz segments are available for 100% duty-cycle utilization after the NOAA satellites become inoperable. Use of the 137.025 - 137.175 MHz and 137.825 - 138 MHz segments must be time-shared with NOAA; and the 149.95 - 150.00 MHz band (allocated LMSS, no sea or air use, and shared with RNSS) and the 149.855 - 149.9 MHz band (time-shared with VITA), plus the 148.905 - 149.81 MHz band (dynamically shared with Orbcomm and System B) for uplink. Alternatively, System B can support a low power spread spectrum CDMA approach with the uplink operating on a shared basis with Starsys's CDMA in the 148 - 148.905 MHz spectrum or on a shared basis with System A and Orbcomm in the 148.905 - 149.81 MHz spectrum.

- Total Downlink Capacity [137 - 138 MHz] 820 Mbits/day
  equivalent to NPRM System 2 downlink
  As a percentage of Orbcomm capacity 92%

- Uplink [148.905 - 149.81 MHz & 149.855 - 149.9 MHz & 149.95 - 150.00 MHz]

Available uplink spectrum	
DCAAS sharing w/Orbcomm	905 kHz
+ 50% of System 1 Uplink	42.8 kHz
effectively reduced by 5% for coordination w/VITA, NPRM@46	
- 50 kHz for avoiding Orbcomm's gateway	-50 kHz
- Gateway spectrum	-50 kHz
balanced with downlink	
= Effective subscriber spectrum	848 kHz
x 1,160 Mbits per day / 945 kHz	1,041 Mbits/day
+ 50% of NPRM System 3 uplink capacity	94 Mbits/day
Total Uplink Capacity	1,135 Mbits/day
As percentage of Orbcomm capacity	98 %

System-B provides 92% of Orbcomm's balanced capacity and is capable of addressing Land, Maritime, and Aeronautical Mobile Satellite Services.

Orbcomm Modification

On 15 November 1994, Orbcomm filed a proposed modification to its authorized system seeking to use an additional 150 kHz of uplink spectrum in the 149.9 - 150.05 MHz band and an additional 90 kHz of downlink spectrum in the 137 - 138 MHz band, and to operate 12 additional satellites. Even without the additional satellites, this modified Orbcomm system would have more capacity then the reference standard Orbcomm system.

- Downlink [137 - 138 MHz]

Available downlink spectrum	410 kHz
-15.6% for gateway operation	-64 kHz
= Equivalent 138 MHz subscriber downlink spectrum	346 kHz
x 1,160 Mbits per day / 270 kHz	1,486 Mbits/day
Total Downlink Capacity	1,486 Mbits/day
As a percentage of Orbcomm capacity	128%

- Uplink [148.905 - 150.05 MHz]

Orbcomm capacity	1,160 Mbits/day
+NPRM System 3 uplink capacity	187 Mbits/day
Total Uplink Capacity	1,347 Mbits/day
As a percentage of Orbcomm capacity	116%

Modified Orbcomm provides 116% of Orbcomm's balanced capacity.

APPENDIX C

APPENDIX C

PROPOSED RULE AMENDMENTS TO 47 C.F.R. PART 25 OF THE COMMISSION'S RULES

§ 25.142 Licensing Provisions for the Non-Voice, Non-Geostationary Mobile-Satellite Service

(a)(4) Each applicant for a space station system authorization in the non-voice, non-geostationary mobile-satellite service must demonstrate, on the basis of the documentation contained in its application, that it is financially qualified to meet the estimated costs of the construction and launch of all proposed space stations in the system and the estimated operating expenses for one year after the launch of the initial space station. Financial qualifications must be demonstrated in the form specified in §§25.140(c) and (d). In addition, applicants relying on current assets or operating income must submit evidence of a management commitment to the proposed satellite system. Failure to make such a showing will result in the dismissal of the application.

3. Sections 25.257 and 25.258 are added to Subpart C to read as follows:

§ 25.257 Time Sharing Between NOAA Meteorological Satellites and NVNG Satellites in the 137-138 MHz band

(a) An NVNG licensee time-sharing spectrum in the 137-138 MHz band shall not transmit signals into the "protection areas" of National Oceanic and Atmospheric Administration ("NOAA") satellites. The protection area shall be calculated by using ephemeris data and an earth station elevation angle of ~~zero~~ **five** degrees towards the NOAA satellite. The NVNG licensee is responsible for obtaining the necessary ephemeris data **from NOAA**. This information shall be updated system-wide on at least a biweekly basis.

(b) NVNG licensees shall establish a 24-hour per day contact person and telephone number so that claims of harmful interference into the NOAA earth stations and other issues can be reported and resolved expeditiously. This contact information shall be made available to NOAA.

(c) NVNG satellites shall ~~be designed to cease transmission automatically if, within a forty-eight hour period, a valid reset signal has not been received from the NVNG gateway Earth station~~ **establish dual redundant fail safe procedures to ensure that the satellite does not operate in a NOAA exclusion zone**. All NVNG satellites shall be capable of instantaneous shutdown on any sub-band upon command from the gateway earth station.

§ 25.258 Time Sharing Between DoD-NOAA Meteorological Satellites and NVNG Satellites in the 400.15-401 MHz band.

(a) An NVNG licensee time-sharing spectrum in the 400.15-401.0 MHz band shall not transmit signals into the "protection areas" of Department of Defense ("DoD") National Oceanic and Atmospheric Administration ("NOAA') meteorological satellites. The protection area shall be

calculated by using ephemeris data and an earth station elevation angle of ~~zero~~ **five** degrees toward the DoD-NOAA meteorological satellite. The NVNG licensee is responsible for obtaining the necessary ephemeris data **from DoD-NOAA**. This information shall be updated system-wide on at least a weekly basis.

(b) NVNG licensees shall establish a 24-hour per day contact person and telephone number so that claims of harmful interference into DoD-NOAA earth station users and other operational issues can be reported and resolved expeditiously. This contact information shall be made available to DoD-NOAA.

(c) NVNG satellites shall ~~be designed to cease transmissions automatically if, within forty-eight hours, a valid reset signal has not been received from the NVNG gateway earth station~~ **establish dual redundant fail safe procedures to ensure that the satellite does not operate in a DoD-NOAA exclusion zone**. All NVNG satellites shall be capable of instantaneous shutdown on any sub-band upon command from the gateway earth station.

(d) Notwithstanding other provisions of this section, NVNG satellites sharing the 400.15-401 MHz with DoD-NOAA meteorological satellites shall implement within ~~ninety~~ **120** minutes of receiving notice of a DoD-NOAA system frequency change, all appropriate modifications and updates to operate on a non-interference basis in accordance with subsection (a), above.

(e) At DoD-NOAA's instruction, the Little LEO System-~~3~~ **A** operator will test, ~~up to four times~~ **at least once** a year, the Little LEO system's ability to implement a DoD-NOAA requested frequency change.

APPENDIX D

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of:	)	
	)	
Amendment of Part 25 of the Commission's	)	
Rules to Establish Rules and Policies	)	
Pertaining to the Second Processing Round	)	IB Docket No. 96-220
of the Non-Voice, Non-Geostationary Mobile	)	
Satellite Service	)	

ANALYSIS OF ELEVATION ANGLE PROTECTION REQUIREMENTS FOR THE NOAA AND DMSP METEOROLOGICAL SATELLITE SYSTEMS

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ANALYSIS OF ELEVATION ANGLE PROTECTION REQUIREMENTS FOR THE NOAA AND DMSP METEOROLOGICAL SATELLITE SYSTEMS

I. METEOROLOGICAL EARTH STATIONS OPERATING AT 137 - 138 MHz AND 400.15 - 401 MHz SHOULD BE PROTECTED ONLY WHILE THE ASSOCIATED SATELLITES ARE LOCATED AT ELEVATION ANGLES OF FIVE DEGREES OR GREATER

Consistent with applicable functional requirements, performance factors, and international frequency sharing criteria, meteorological earth station receivers operating at 137-138 MHz and 401.5 - 401 MHz should be protected only while the associated satellites are located at elevation angles of five (5) degrees or greater. There generally are no functional requirements to receive "direct readout" data[1] from meteorological satellites at elevation angles less than five degrees because the associated geographic areas are too limited and distant to indicate current and evolving meteological conditions. Even if reception of data at lower elevation angles were desired, the received data (if any) generally would be too flawed to be of value as a result of signal degradation due to atmospheric refraction and multipath phenomena. Accordingly, a minimum elevation angle of five degrees is specified for interference and frequency sharing criteria adopted internationally for meteorological-satellite earth stations.

A. FUNCTIONAL REQUIREMENTS GENERALLY PRECLUDE ANY NEED FOR OPERATION AT ELEVATION ANGLES LESS THAN FIVE DEGREES

Real-time data transmitted by meteorological satellites may consist of soundings (e.g., atmospheric temperature profiles sampled in the nadir direction) as well as images (e.g., raster-

[1] "Direct readout" data consist of the data that are collected by sensors on the satellite and transmitted in real-time.